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24. *L. Turneri* E. & E. Ground pastures and open woods. Orono, Greenfield, Sept. and Oct. (Harvey.)

25. L. *subincarnatum* Peck. Growing in clusters on decaying wood, Greenville. Orono and Norcross. (Harvey.) August.

26. *L. Curtisii* Beck. In pastures. Orono. (Harvey.)

27. *L. separans* Peck. Ground in pastures, Orono, Me. Very abundant in October. (Harvey.)

28. *L. pedicillatum* Peck. Ground and on rotton wood. Orono, Me. (Harvey.)

29. *Scleroderma vulgare* Hornem. Western Me. (Blake.) Orono, under fir trees and at Pea Cove on decaying logs. (Harvey), Belfast (Uptom) E. Auburn (E. D. Merrill).

Further Considerations of the Biological Status of Lichens.

By Albert Schneider.

In a previous number of the Bulletin I have given a brief statement of the biological status of lichens. The paper was essentially a restatement of Reinke's views on the subject. The present object is to continue the discussion and to present different phases and other details. Limited space will not permit entering into lengthy discussions, nor is this called for, since the details here touched upon have already been fully discussed elsewhere. The intended function of this paper is primarily educational, pointing out the best method by which the conscientious student may arrive at a rational conclusion relative to the nature of lichens. This seems necessary since many botanists (in verbal communication) are most persistent in designating and classifying lichens as fungi (in agreement with Schwendener). And this is not all; some so-called lichenologists are just beginning to take notice of Schwendener's theory and wonder "whether there is anything in it," while others have not even heard of this theory or ignore it entirely.

The stubborn resistance offered to the recognition of lichens as a distinct class (in the sense of Reinke, not Tuckerman, Acharius and others), may be said to have a beneficial influence upon the general progress of lichenology. Controversy and difference of opinion is to science what the governor is to the engine, it insures a more steady progress by urging more thorough study and greater care and consistency in formulating conclusions. It is, however, a fact which cannot be denied that (with a few exceptions) the most vehement objectors to Reinke's theory are those who have little scientific perspective and who have done little or no scientific work in lichenology. Among the more scientific class of botanists the principal cause of the difference of opinion lies in the difference of the point of view. The Schwendenerians are essentially morphologists (histologists) of the older school who consider structure and not function of prime importance. The followers of Reinke are the product of the modern school of biological investigation which teaches that the morpho-physiological method is the true one. That is, it should be the investigator's purpose to give a proper physiological interpretation to the morphological conformation. Peculiarly enough Schwendener is quite universally recognized as the founder of this school. It should also be borne in mind that at the present time Schwendener raises no serious objection to Reinke's views.

Until recent years the pure systematists held full sway. Morphological studies were resorted to simply as an aid to classification; hence those structures which proved most useful in forming or perfecting a system received first attention. In the various systems of fungi the characters of the spore-bearing tissue was found most useful. On comparing the apothecia of lichens with the reproductive organs of fungi, certain morphological similarities were noted and at once the conclusion was reached that lichens must be fungi. No efforts were made to demonstrate whether or not the spores of lichens were functionally the same as those of the fungi. The study of the thallus was neglected because it was not clear what practical use could be made of it in classifying lichens as fungi. Schwendener himself, as well as many investigators before and after him, made careful morphological investigations of the various lichen-thalli. Schwendener indeed demonstrated that the gonidia in the majority of lichens were true algae, but he did not give a true explanation of the relationship existing between the fungus and the enclosed algae (gonidia). Reasoning from the standpoint of morphology he concluded that lichens were the result of the parasitism of fungi with algae, a conclusion without any physiological basis, as later investigators have demonstrated.

Eminent investigators, after years of careful study attempting to give a corresponding physiological interpretation to the morphological specializations as they occur in the lichen-thallus, have concluded that it cannot be compared to any fungal structure.

The recent progress in the study of the phenomena of mutualistic symbiosis has a very important bearing upon the recognition of the true nature of lichens. There are botanists who are scientifically so unprogressive as to recognize no other form of symbiosis * than "parasitism" (antagonistic symbiosis). Such will, of course, persist in maintaining the "parasitic" nature of lichens. There are all gradations between mutual antagonistic symbiosis (mutual parasitism) and complete individualism.† Upon a recognition of these phenomena depends the proper consideration and treatment of lichens. Furthermore, the phenomena of symbiosis have an important bearing upon the modern conception of the cell, some problems in evolution, and upon the interdependence of plants and animals. It is intended to define and discuss these phenomena in some future paper.

Symbiosis has also a direct bearing upon the consideration of what constitutes a morphological unit. When a form of symbiosis has reached the stage of complete individualism there can be no doubt that the resulting structure constitutes a morphological unit in the true sense of the word. The important question at this phase of the subject is whether or not the form of symbiosis as it occurs in lichens is sufficiently specialized that the resulting structure may be recognized as being autonomous. In attempting to solve this problem it is necessary to consider the following: 1. Is the lichen-structure morphologically and physiologically distinct from the symbionts? 2. Have the symbionts wholly or partially lost the power of independent existence?

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* The term is here used in its broader meaning. It includes all forms of contiguous associations of two or more morphologically distinct organisms accompanied by a loss or acquisition of assimilated food-substances.

† Complete individualism is a form of mutualistic symbiosis in which *none* of the symbionts can exist independently (examples: some of the higher lichens, the cell). Semi-individualism is a form of mutualistic symbiosis in which at least *one* of the symbiants cannot exist independently (the Collemas and other lichens).

The first question has already been answered in the affirmative by Reinke, Bonnier, Bornet and others. The second will receive some further consideration. As far as lichens are concerned investigators are quite generally agreed that the fungal symbiont can no longer lead an independent existence. It is absolutely dependent upon its symbiotic association with the algae. It is also generally believed that the algae (gonidia) can exist independently. At least, many of the lichen-algae have been cultivated in artificial media. Some recent experiments in this line would lead me to conclude that the algae of some of the higher lichens can not exist independently for any considerable period of time. It became apparent at once that related single-celled algae occurring free in nature develop more readily than the lichen-algae when placed in or on artificicial media. Repeated attempts to cultivate the algae (*Cystococcus humicola* Näg.) of *Cladonia* have only partially succeeded. The algae would soon acquire an impoverished appearance; changing from bright green to yellowish green and finally to a pale straw color. Cell-division occurred only rarely and at long intervals during the beginning of the experiment. Soon cell-division and growth ceased altogether. In some of the experiments a species of natural algae (*Protococcus viridis* and another species) accidentally introduced developed rapidly, soon forming a green layer over the substratum (schistose rock, sandstone, limestone). These natural algae frequently occur upon the surface of the lichen-thallus and are apt to gain access to the culture media. They can, however, readily be gotten rid of by the isolation method. Culture attempts with algae (*Cystococcus humicola* Näg.) from several species of *Parmelia* gave similar results. In no case was it possible to develop a colony of any considerable size nor could the growth of the culture be maintaned for any considerable period of time. From these experiments the conclusion seems justifiable that the algae of some of the higher lichens are no longer capable of leading a continued independent existence. Fungus and alga, during their association as lichen, have become mutually adapted so that they are complimentary in their relationship as a morphological whole. It is safe to conclude that at least some of the lichens form absolute individualism. Even the most prejudiced, therefore, cannot hesitate in recognizing such lichens as morphological units. In regard to the lower lichens and some of the higher (Nostoc-bearing) there seems to be evident semi-individualism, though further carefully conducted experiments are necessary to settle this point.

Without entering into details I shall briefly summarize the essential differences between lichens and the ascomycetous fungi. This summary is deduced from the results obtained by the most scientific lichenologists during the past forty or fifty years. These statements are especially intended for those who are continually forgetting that there is a difference between fungi and lichens.

1. The morphological adaptions of the vegetative portion of lichens is primarily for the furtherance of the function of *chlorophyll-assimilation*; in fungi it is for the furtherance of the function of *reproduction* (distribution of spores, etc.).

2. Fungi are essentially parasitic and saprophytic. Lichens have partially or wholly lost the saprophytic or parasitic function and have phylogenetically acquired the power of converting inorganic substances into organic compounds by a process of photosynthesis. Morphologically and physiologically lichens resemble other chlorophyll-bearing plants; fungi do not.

3. In lichens the mechanical tissues * are specially adapted to support and protect the assimilation tissue; in fungi the mechanical tissue is specially adapted to support and protect the sporogenous tissue.

4. The soredia of lichens are special phylogenetically-derived propagative organs and have no homologues among the fungi. The cyphellae and cephalodia are also phylogenetically derived lichen-structures.

5. The spores of fungi can develop into mature fungi; the spores of lichens cannot develop into mature lichens. In other words fungi may develop from spores, lichens cannot.

6. Lichens are better adapted to resist extremes of temperature and dryness. Fungi are better adapted to dark moist places.

7. In general lichens are long-lived while fungi are short-lived. Some of the higher as well as the lower lichens (*Cladonia*, *Par-*

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* More fully described by Zukal and in my Text-book of General Lichenology now in press. In this book the citations of the more important literature on lichenology will be given.

melia, Sticta, Lecidea, Biatora) have an indeterminate existence. The life-period does not terminate with the maturation of the spores, as with the majority of fungi.

8. The spore-bearing tissue of lichens is of little functional value, hence it degenerates or becomes converted into a chlorophyll-bearing assimilating tissue (sterile *Parmelias* and *Cladonias;* podetia of *Cladonia*, thalloid exciple). Among the fungi the sporogenous tissue becomes functionally more and more specialized.

9. Lichens contain chemical compounds (lichenin, acids, etc.) which do not occur among fungi.

10. Morphological similarities (in the vegetative tissues of lichens and fungi they rarely occur) do not indicate similarity in function. (See 1.)

Finally I will again urge the necessity of conducting modern biological research from the standpoint of morpho-physiology. It will be productive of reliable and harmonious conclusions.

The Affinities of Dendrobangia Rusby.*

By H. H. Rusby.

(Plate 294.)

The family Olacineae, as treated by Bentham and Hooker (Gen. Plant, 1: 342 and 995) comprises four tribes. Olaceae has the ovary normally 3–5-celled, occasionally 1-celled by suppression, with two pendulous ovules in each cell. Opilieae has the ovary 1-celled, with one erect ovule. Icacineae has the ovary normally 1-celled with two, rarely one by abortion, unilaterally dendulous ovules. Phytocraneae has characters very similar to those last mentioned.

Dr. Engler (Pflanzenfamilien, 3: Abt. 5, 233) separates the two tribes last mentioned, under the family Icacinaceae, grouping them with the Aceraceae, Celastraceae and Anacardiaceae, referring the Euphorbiaceae, also to this group. The two tribes first mentioned he retains in the family Olacinaceae and groups them with the Aristolochiaceae, Loranthaceae and Urticaceae.

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* Mem. Torr. Bot. Club, 6: 19.